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ABSTRACT

The effect of aerobic exercise on total cholesterol (TC), high-density lipoprotein (HDL), apolipoprotein B (Apo B), apolioprotein A-I (Apo A-I), and percent body fat in adolescent females was studied. The control subjects (n=86) were volunteers who had completed a physical education class at least six months prior to the commencement of the study, and the treatment (n=79) subjects were volunteers who were newly enrolled in the investigator's physical education classes. All subjects were pretested and posttested on the dependent variables. The treatment subjects participated in a 12-week aerobic exercise program during their physical education classes. Their TC, Apo B, and body fat levels decreased significantly while their HDL and Apo A-I levels did not change. The control group's TC and HDL decreased with no changes in other varieties. When the treatment and control groups were compared, the treatment group had significantly lower body fat and Apo B levels and higher HDL. Findings of this study support the conclusion that modification of Apo B and body fat, risk factors for cardiovascular disease (CVD), may be possible during adolescent years through participation in aerobic exercise. However, longitudinal studies are necessary to determine if adolescent CVD risk modification, involving aerobic exercise, can reduce future CVD risk. (Author/IAH)

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The Effect of Aerobic Exercise on Total Cholesterol, High-Density Lipoprotein, Apolipoprotein B, Apolipoprotein A-I, and Percent Body Fat in Adolescent Females

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Running Head: EFFECT OF AEROBIC EXERCISE

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Abstract

The effect of aerobic exercise on total cholesterol (TC), high-density lipoprotein (HDL), apolipoprotein B (Apo B), apolipoprotein A-I (Apo A-I), and percent body fat in adolescent females was studied. The control subjects (n = 86) were volunteers who had completed a physical education class at least six months prior to the commencement of the study, and the treatment (n = 79) subjects were volunteers who were newly enrolled in the investigator's physical education classes. All subjects were pretested and posttested on the dependent variables. The treatment subjects participated in a 12-week aerobic exercise program during their physical education classes. Their TC, Apo B and body fat levels decreased significantly while their HDL and Apo A-I levels did not change. The control group's TC and HDL decreased with no changes in other varieties. When the treatment and control groups were compared, the treatment group had significantly lower body fat and Apo B levels, and higher HDL.

The Effect of Aerobic Exercise on Total Cholesterol, High-Density Lipoprotein, Apolipoprotein B, Apolipoprotein A-I, and Percent Body Fat in Adolescent Females

During the 1980's, cardiovascular fitness objectives for adolescents were set by many concerned institutions ranging from the United States Department of Health and Human Services to local school districts (Allensworth & Wolford, 1988; "Secondary Core Curriculum," 1987; "Alpine Curriculum," 1989). Included in these fitness objectives was a directive for adolescents to engage in aerobic exercises for 15 to 20 minutes a day, three times a week as a minimal recommendation. But, what effect does participation in such a program have on the health of the adolescents? This concern for the improvement of cardiovascular fitness in adolescents will be of value only if it leads to the prevention of disease and, possibly, premature death.

Researchers have suggested the existence of an inverse relationship between physical activity and mortality in adults. Two different investigations have

shown that men and women who maintain moderate levels of physical fitness appear protected against premature death due to cardiovascular disease (CVD) (Blair, Kohl, Paffenbarger, Clark, Cooper, & Gibbons, 1989; Ekelund, Haskell, Johnson, Whaley, Criqui, & Sheps, 1988). We do not have such information for adolescents.

Research findings of epidemiological and clinical studies have identified health factors which place an individual at risk for CVD. These health factors, called cardiac risk factors, have been classified into two categories, non-modifiable or modifiable. Non-modifiable risk factors for CVD are age (older people run a higher risk), gender (male), and genetics (race, coronary anatomy, and family history of disease). Modifiable risk factors for CVD include hypertension, abnormal serum lipids, cigarette smoking, diabetes mellitus, lack of physical activity, and obesity (Margolis, 1981). Initially, these risk factors were studied only as a concern of adults. However, more recently, the Bogalusa Heart Study established that risk factors for atherosclerosis were also evident in

children (Berenson et al., 1988). Thus, further research involving cardiac risk factors should not only be a concern for adults, but also for children and adolescents.

Reviews of numerous studies on adults have both confirmed and disputed the effect of physical activity and fitness on lipid and lipoprotein levels (Goldberg & Elliot, 1985; McCurney, 1987; and Superko, Haskell, & Wood, 1985). Despite the conflicting results, the reviewers concurred that there were significant data supporting the conclusion that physical activity is associated with a reduction in the progression of coronary heart disease (CVD).

Increased low-density lipoprotein (LDL) levels have been associated with the development of one form of CVD, atherosclerosis (Hancock, 1987). In contrast, increased high-density lipoprotein (HDL) levels have been negatively correlated to atherosclerosis (Castelli, Garrison, & Wilson, Abbott, Kalousdian, & Kannel, 1986); thus, high HDL levels seem to have a protective effect against CVD.

Increased HDL levels in relation to physical activity had been associated with a decrease in percent body fat (Wood, Stefanick, Dreon, Frey-Hewitt, Garay, Williams, Superko, Fortmann, Albers, Vranizan, Ellsworth, Terry, & Haskell, 1988). However, in one study HDL levels did not change after nine weeks of aerobic exercise on sedentary men whose body fat remained unchanged (Raz, Rosenblit, & Kask, 1988). Thus, the effect of physical activity on lipoproteins may not be independent of a decrease in body fat.

The effect of physical activity and fitness on lipid, lipoprotein, and apolipoprotein levels has been studied less often in adolescents than adults (Sallis, Patterson, Buono, Nader, 1988; Schwartz, 1988). Researchers of four different studies involving children and adolescents concluded that physical exercise and fitness were related to lower total cholesterol (TC) and high HDL levels (DuRant, Linder, Harkness, & Gray, 1981; DuRant, Linder, & Mahoney, 1983; Tell & Vellar, 1988; and Yamamoto, Horibe, Sawada, Uyama, Matsuzawa, Yamamura, Yokoyama, Kasagi, & Kameda, 1988).

Although research has not been able to definitely prove that high cholesterol levels in childhood lead to high levels in adulthood, a child with high cholesterol level is at greater risk for a high level in the future. Berenson et al. (1988) found that TC and LDL levels "track" well from childhood into adulthood.

The purpose of this study was to determine the effect of aerobic exercise on serum TC, HDL, Apo B, Apo A-I, and percent body fat in adolescent females. It was predicted that TC levels, Apo B levels, and percent body fat would decrease in response to aerobic exercise and that HDL and Apo A-I levels would increase in response to the same exercise.

Methods

Subjects (n = 165) for this study were volunteer female students, ages 12 to 15 years from the investigator's seventh-, eighth-, and ninth-grade physical education classes at Orem Junior High of Alpine School District in Orem, Utah. Informed consent was obtained from all subjects and their parents prior to testing.

The treatment group (n = 79) consisted of students newly enrolled in the investigator's physical education classes winter semester 1989. These students had not participated in any formal physical education classes for at least the previous six months. The control subjects (n = 86) were the investigator's former physical education students who were not currently involved in physical education or any other formal exercise program.

Prior to commencing the study, the treatment subjects were taught the importance of exercising to the proper intensity level and how to check this intensity as described by Simons-Morton, Date, and Simons-Morton, (1988). The subjects also agreed to maintain a target heart rate zone (THRZ) between 60% to 80%. Prior to the first exercise session, subjects also learned to convert their THRZ from beats per minute to beats per 10 seconds, an easier method of checking their exercise intensity. Pulses were counted at the carotid artery.

The treatment consisted of subjects participating in an aerobic exercise program three times per week for

12 consecutive weeks during their regularly scheduled physical education classes. Classes lasted 45 minutes, with a five minute static stretching warm up, a 20-minute aerobic exercise period, where the THRZ was attained, and a five-minute walking cool down. The remainder of the time was used for dressing and attendance procedures. After each aerobic workout the subjects recorded on a log sheet the type of exercise completed and the duration of the exercise session and their second THRZ. These sheets were collected and inspected by the investigator each day and then given back to each subject before the next exercise session.

Subjects in both the treatment and control groups had no regular exercise program of their own. They were allowed to participate in occasional recreational activities if they desired.

Two certified medical technologists from Brigham Young University in Provo, Utah, collected a baseline venous blood sample from all subjects before the treatment period began. At the end of the treatment period, the same technologists collected another sample in the same manner. Each subject's pre- and posttest

blood samples were taken at the same time of day, according to when their physical education class was scheduled. Because of the public school setting and the necessity of children eating their regular meals, it was not possible to have them fast before each blood sample was collected. Collection was under aseptic conditions in a room provided by the school, with only two subjects present per drawing. The samples were analyzed in the Medical Technology Laboratory of the University by the same Ph.D. in microbiology/medical technology.

The sera were analyzed on a Multistat III Plus instrument. The reagents used for the total cholesterol (TC) and high-density lipoprotein-cholesterol (HDL-C) analysis were purchased from Data Medical Associates (DMA). The reagents used for the Apo B and Apo A-I analysis were purchased from Reagents Applications, Inc. (RAI). TC was analyzed using the DMA Enzymatic Cholesterol Reagents on the Multistat III Plus system. HDL-C was analyzed using DMA HDL Precipitating Reagent and Data-Zyme Cholesterol Reagent on the same system. Apo B and Apo A-I were analyzed

turbidimetrically utilizing the Multistat III Plus system and the Raichem Serum Protein Immuno Assay Apo B and Apo A-I Reagents purchased from RAI.

All subjects' percent body fat was calculated using the method of Sloan & Weir (1970) for females, by a certified athletic trainer from Brigham Young University using Harpenden calipers and the Sloan-Weir Nomogram. Pre- and posttreatment measurements were taken from each subject.

Covariance analysis (ANCOVA) was used to compare the difference between the treatment and control groups' TC, HDL, Apo B, Apo A-I levels, and percent body fat, with the pretest as the covariate. Additionally paired comparison t-tests were used to test for a significant change in the above variables from pretest to posttest within each group. Table 1 contains pretest and posttest means and standard deviations, ANCOVA adjusted means with their accompanying F-ratios and probability levels for each variable.

Insert Table 1 about here

Significant F-ratios were calculated for three of the variables. The treatment group exhibited a significantly higher HDL level $F(1,162) = 6.15$, $p < .0144$, than the control group. Treatment subjects also displayed lower Apo B levels $F(1,162) = 20.31$, $p < .0001$, than the control's, and their percent body fat was likewise significantly lower $F(1.147) = 7.84$, $p < .0058$, than the control group's.

The ANCOVA did not show any significant differences between the two groups for TC and Apo A-1.

Within group comparisons using a paired comparison t-test were calculated to examine any changes from pre- to posttest that may have taken place. For the treatment group, TC was significantly lowered $t(79) = 3.96$, $p < .0002$, Apo B decreased also, $t(79) = 5.11$, $p < .0001$, and percent body fat decreased also, $t(72) = 2.89$, $p < .0052$. There was no change in the treatment group's HDL and Apo A-1 levels.

The control group's TC decreased $t(86) = 4.75$, $p < .0001$, and its HDL also decreased $t(86) = 4.82$, $p < .0001$. There were no changes in the Apo B, Apo A-1, and percent body fat levels for the control group.

Discussion

This study demonstrated that adolescent females who participated in an aerobic exercise program for 12 weeks exhibited more favorable blood serum cholesterol, lipoprotein, apolipoprotein levels and percent body fat than the control subjects. Their HDL levels were significantly higher than the control's, thus lessening their chances of acquiring atherosclerosis, according to Hancock (1987). This difference in HDL levels between the groups is not because the exercise subjects increased their HDL, because they did not, rather it is because the control groups HDL significantly dropped, perhaps due to continued lack of exercise. The fact that the HDL levels of the exercise group did not increase is consistent with the research findings of Hooper and Norland (1984), Williford, Blessing, Barksdale and Smith (1988), and Raz, Rosenblit and Kask, (1988).

Apolipoprotein B, the primary protein of LDL was found to be significantly lower in the treatment group than in the control group. Also, the treatment group significantly lowered its Apo B level during the 12 week exercise period while their was no change in the control's level. Thus it appears that the 12 week aerobic exercise treatment could very well serve as a protector against CVD. In fact, the research of Jacobsen and Lillienfeld (1988) and Naito (1988) indicated that Apo B may be a more accurate marker for cardiac risk than LDL.

The last comparison which yielded significance between groups was the test for percent body fat. The fact that the treatment group was significantly lower than the control, and that they also lowered their percentage from pre to posttest confirms what we already knew, that aerobic exercise can reduce body fat.

Finally, we were surprised to find that the analysis showed no difference in TC between the two groups and that both groups demonstrated significant decreases from the pre- to posttests. It was

anticipated that only the treatment group would show lowered TC levels, and that this group's level would also be lower than the control's. Further, it was not entirely understood how TC in both groups decreased while Apo B, the protein portion of LDL, significantly decreased for only the treatment group. One explanation could be that the immunoassay procedure for Apo B is probably a more sensitive procedure than the common spectrophotometric cholesterol procedure used for TC.

In conclusion, findings of this study support the conclusion that modification of Apo B and body fat, risk factors for CVD, may be possible during adolescent years through participation in aerobic exercises. However, longitudinal studies are necessary to determine if adolescent CVD risk modification, involving aerobic exercise, can reduce future CVD risk and, possibly, premature death.

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The Multistat III Plus Analyzer was donated by Instrumentation Laboratories. The reagents used for the Apo B and Apo A-I analysis were purchased at a reduced rate from Reagents Applications, Inc.

Table 1

Means, Adjusted Means and Standard Deviations of Lipid Measurements and % Body Fat

Variable	Treatment Mean**	SD	Control Mean**	SD	F	P
TC Pretest	161.58[a]	22.63	173.63[a]	24.36		
TC Posttest	153.26	24.24	164.43	22.93		
TC Adjusted*	157.04		158.96		0.47	.4920
HDL Pre-test	53.78	9.36	56.25[a]	10.22		
HDL Posttest	53.51	9.18	52.34	9.14		
HDL Adjested*	54.29		51.61		6.12	.0144
Apo B Pretest	62.20[a]	14.94	62.46	15.09		
Apo B Posttest	55.90	13.02	63.20	13.20		
Apo B Adjusted*	56.06		63.13		20.31	.0001
Apo A-I Pretest	102.66	14.75	113.48	24.94		
Apo A-I Posttest	102.67	16.97	112.71	28.52		
Apo A-I Adjusted*	107.48		108.29		0.10	.7530
% Fat Pretest	17.608[a]	3.52	18.325	4.071		
% Fat Posttest	17.17	3.39	18.09	4.04		
% Fat Adjusted*	17.31		17.95		7.84	.0058

*Adjusted measures were computed by statistically controlling for any pre-existing differences among the groups that may have existed.

[a]Significant difference between pretest and posttest means within groups.

**Means are reported in mg/dL for all variables except % body fat.

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